MODELLING GROWTH FROM WEANING TO MATURITY IN BEEF CATTLE BREEDS

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Background

- **Industry problems:**
  1) Concern about cattle getting too big in mature weight:
     - 1972 Average weight of choice steers 509.8 kg [1]

       2017 Average weight of federally inspected cattle 621.0 kg [2]
     - DMI increases with increased body size

  2) Cannot directly compare EPD from different breeds
     - Different genetic trends, sampling, base years, etc.
     - Across-Breed Adjustment Factors not available for mature size.

[1] USDA-ERS, Commodity Economic Division. 1973. Livestock and meat situation. http://usda.mannlib.cornell.edu/usda/ers/LMS//1970s/1973/LMS-08-17-1973.pdf (Accessed 24 March 2017.)
[2] USDA-NASS. 2017. Livestock slaughter. http://usda.mannlib.cornell.edu/usda/nass/LiveSlau//2010s/2017/LiveSlau-03-23-2017.pdf (Accessed 24 March 2017.)

Objective

- Characterize and compare growth to maturity in beef cattle breeds as a first step towards enabling more informed breed utilization:
  - **Breed types:** British, Continental, and Brahman-Influenced
  - **Functions:** Brody, spline, and quadratic
  - **Measures compared:** weaning weight, maturing constant, and mature weight

Data Source

- Germ Plasm Evaluation Program (**GPE**)
  - Located at United States Meat Animal Research Center (**USMARC**) in Clay Center, Nebraska, USA
  - Began 1969: Influx of new breeds = need to evaluate incoming breeds for economically important traits
  - Crossbred herd representing current industry in several cycles & continuous sampling

USDA United States Department of Agriculture

Data Source

- After all editing: 102,177 weight records on 4,721 crossbred GPE cows born between 1999 and 2014
  - Dams = mostly Angus, Hereford, and MARC III (1/4 each Angus, Hereford, Pinzgauer, and Red Poll)
  - Sires = Sampled from industry

Editing Rules for Weights

- Weight records truncated at:
  - Feed restriction study
  - Gaps greater than two years between subsequent records
  - 6 years of age
- Birth weight records removed
- Full records removed if cow did not have records in in herd past 3 years of age

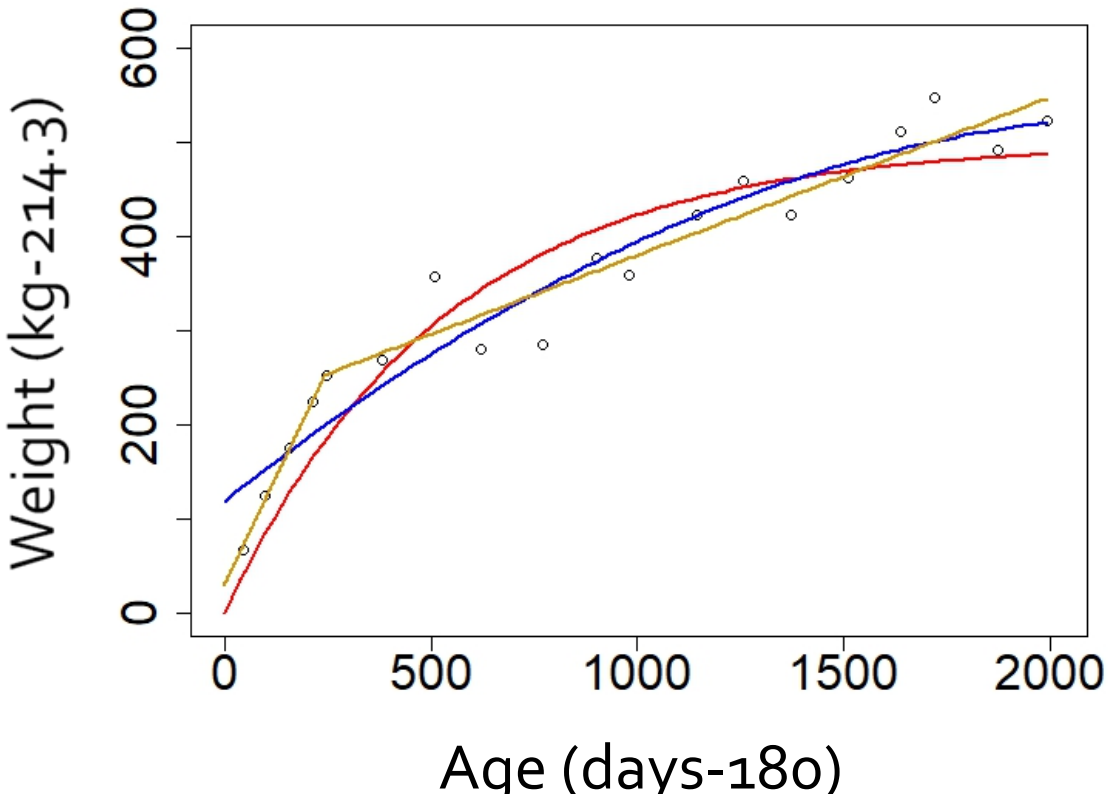
Model Fitting

- Calculate model parameters:
  - Brody: $W_t = A[1 - e^{-k(t-t^*)}]$ using nonlinear least squares function in R (R Core Team, 2017)
  - Spline (1st degree): segmented package in R (Muggeo, 2008)
    - Intercept estimate before knot approximates weaning weight
    - Used estimates after knot to predict mature weight at 6 years of age
  - Quadratic: linear model function in R (R Core Team, 2017)
    - Intercept estimate approximates weaning weight
    - Used coefficients to predict mature weight at 6 years of age

Model Fitting

A visual example of the three curves, fit to one cow's data.

KEY
Brody
Quadratic
Spline



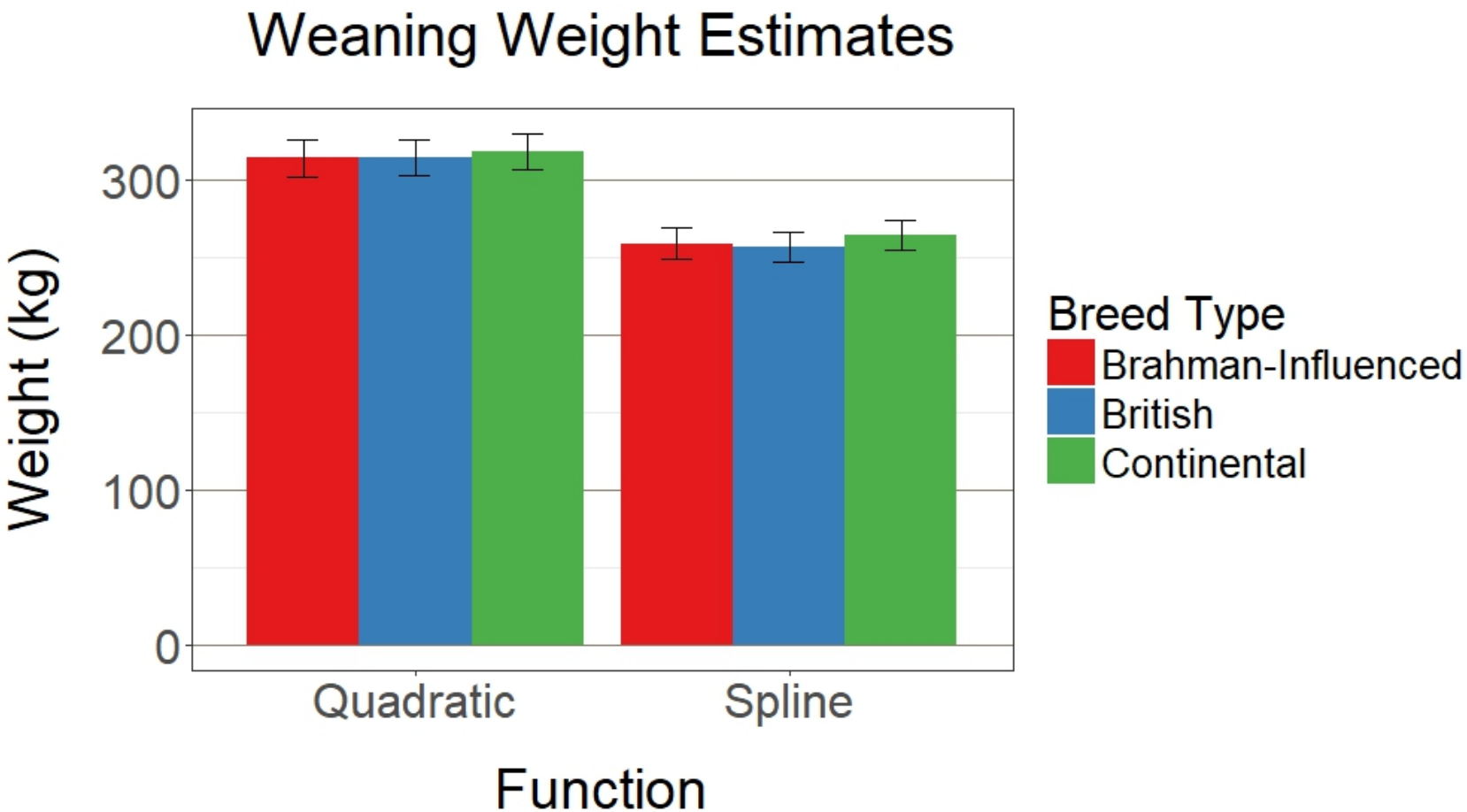
Editing Rules for Parameter Estimates

- Individual's parameter estimates removed if:
  - Pedigree data was missing
  - Any model did not converge
  - Any mature weight estimate was more extreme than 2.2 IQR units from the mean

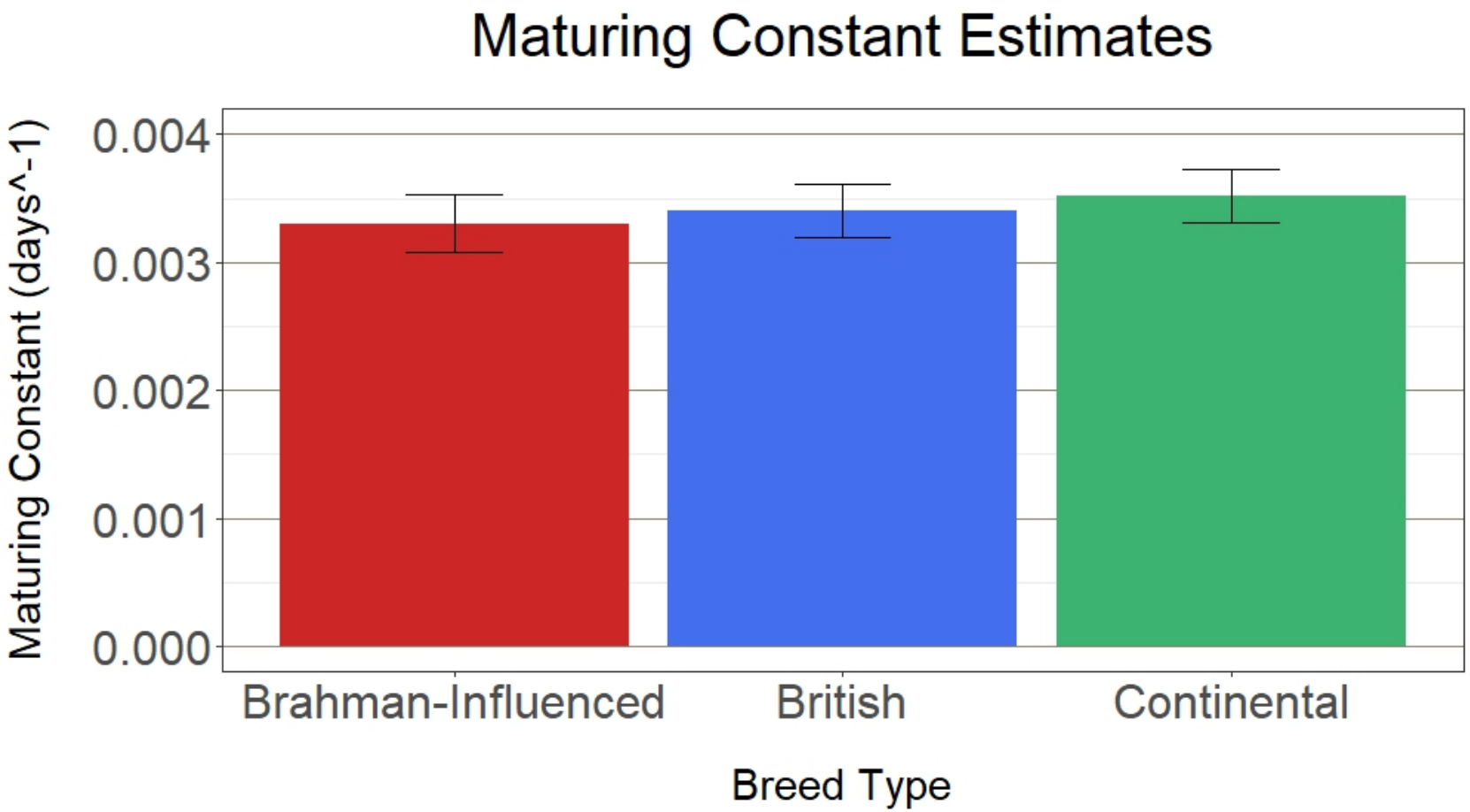
Determining Breed Effects and Heterosis

1. Estimate breed fraction and heterosis from pedigree
2. Determine breed estimates for each parameter using linear model:
   $$parameter\ estimate = breed\ fraction + heterosis + CG + error$$
3. Calculate weighted average of each breed type:
   - **British:** Angus, Hereford, Red Angus, Shorthorn, Chiangus
   - **Continental:** Braunvieh, Charolais, Gelbvieh, Limousin, Maine Anjou, Salers, Simmental
   - **Brahman-Influenced:** Beefmaster, Brahman, Brangus, Santa Gertrudis

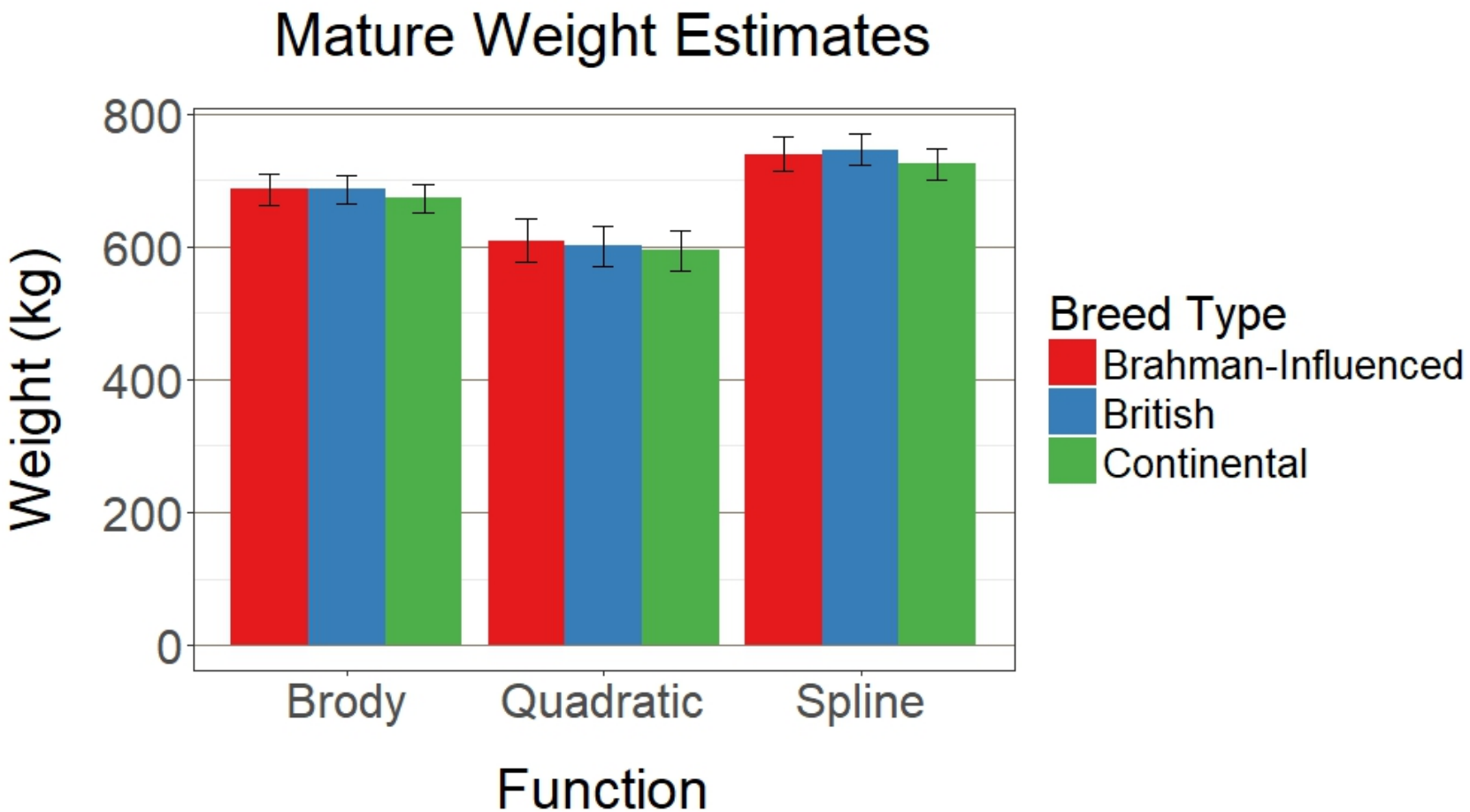
Results


Weaning Weight Estimates
Weight (kg)
300
200
100
0
Quadratic
Spline
Function
Breed Type
Brahman-Influenced
British
Continental

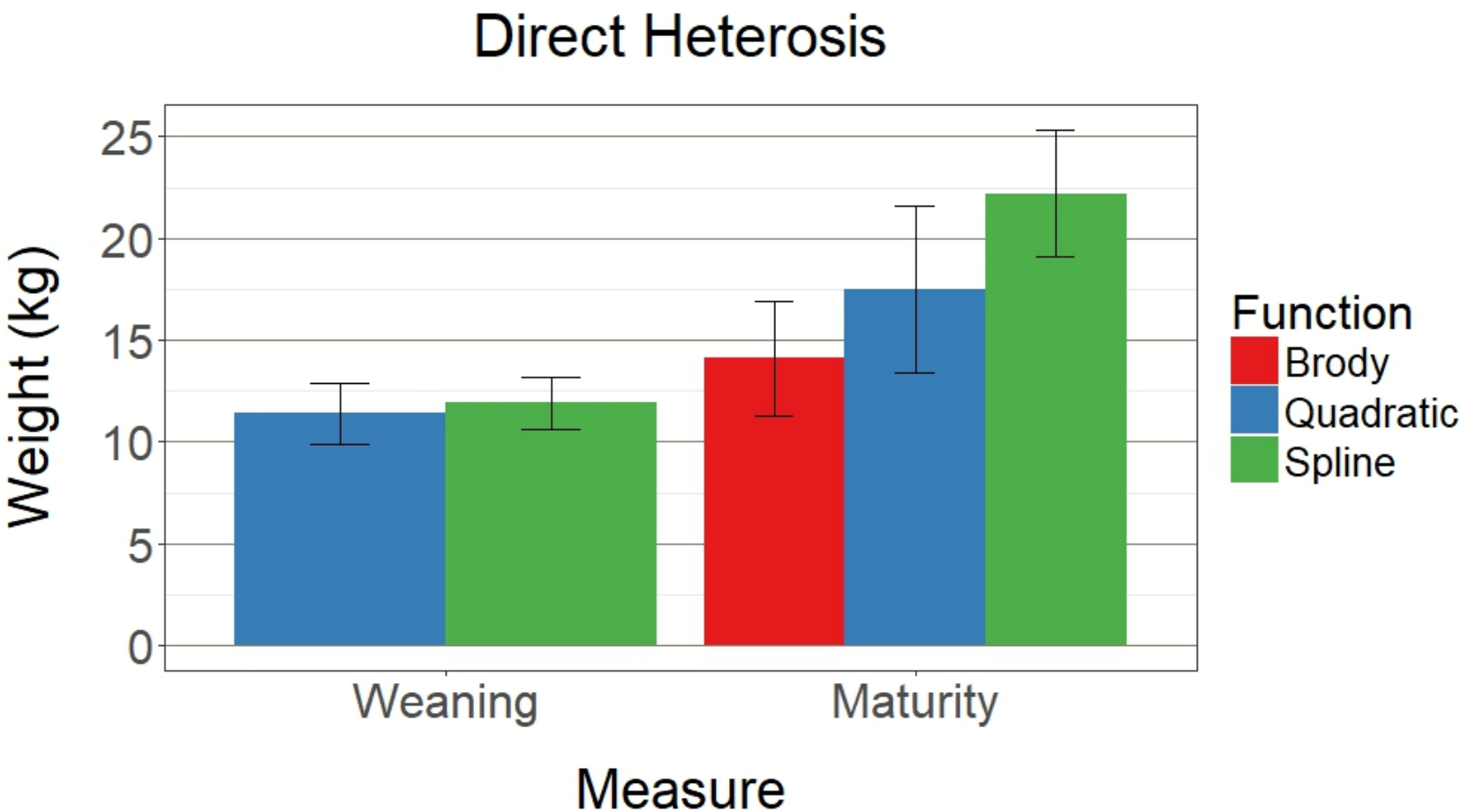
Results


Maturing Constant Estimates
Maturing Constant (days^-1)
0.004
0.003
0.002
0.001
0.000
Brahman-Influenced
British
Continental
Breed Type

Results


Mature Weight Estimates
Weight (kg)
800
600
400
200
0
Brody
Quadratic
Spline
Function
Breed Type
Brahman-Influenced
British
Continental

Results


Direct Heterosis
Weight (kg)
25
20
15
10
5
0
Weaning
Maturity
Measure
Function
Brody
Quadratic
Spline

Conclusions

- Breed types similar at both weaning and maturity within each function.
  - Weaning: Continental breeds tended to be slightly larger than British and Brahman-influenced breeds.
  - Maturing Constant: Near 0.0035 $days^{-1}$
  - Maturity: British and Brahman-influenced breeds tended to be slightly larger than Continental breeds.
- All estimates were somewhat larger than published estimates from the 1980's and 1990's, potentially reflecting genetic trends.

Future Work

- Calculating variance component estimates
- Deriving breed effects and maternal heterosis for mature weight

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